TRANSLATION

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Device for rapidly heating liquids and melts, in particular polymer melts that harden rapidly.

A device for heating liquids and melts rapidly, in particular polymer melts that harden rapidly, which are to be carried through one or more discharge tubes having a small cross-section. The device has a tubular structure located behind the discharge tube and has a flow cross-section which is significantly higher than that of the discharge tube and which is configured such that a short heat diffusion path length, which provides rapid heating, exists over the entire flow cross-section and the overall length of the tubular structure. This allows the liquid to be heated in a few seconds with a high liquid throughput and a tubular structure length of only a few cm.

Description

This invention concerns devices for heating liquids and melts rapidly, in particular polymer melts that harden rapidly, which are to be carried by one or more discharge tubes.

There are a number of critical liquids, such as polymer melts that harden rapidly, which should, on one hand, be e.g. atomizable by means of a narrow liquid jet from a discharge tube having small cross section, and, on the other hand, should accordingly be very rapidly heated to high temperatures. An example of this is a polymer melt which is preheated to about 130°C in an extruder. At this temperature, the viscosity of the aforesaid melt is very high, but its product is stable.

In order to be able to atomize the melt, it must be heated very rapidly to 200°C in an accordingly narrow discharge tube. At this temperature, the viscosity of the melt decreases to a value of 20 Poise, corresponding to that of glycerin, and the melt can be atomized into very fine droplets at the opening of the discharge tube by using an ultrasonic stationary wave atomizer. If the melt is held at a temperature of 200°C for more than four seconds, it polymerizes due to a necessary hardener addition and thus becomes a solid and can thus neither be completely expelled nor atomized.

The device shown in **Fig. 1** clarifies the aforesaid case, wherein the polymer melt **1** is pressed out of an extruder at a temperature of 130°C into a narrow discharge tube **2**, in the manner suggested by the figure. The latter is surrounded by a heating coil which heats the wall of the discharge tube and through it the melt in the discharge tube to 200°C in four seconds. As the following calculation shows, the heat transfer from the heated wall of the discharge tube to the preheated melt can only occur at a certain rate, which depends on the thermal conductivity λ and the specific heat capacity ρc_p of the melt. The heat diffusion constant $æ = \lambda/(\rho c_p)$ (1) is determinative for this process.

The time τ for nearly complete penetration of the thermal front to the center of the discharge tube, i.e. to the point where the melt is heated to the new equilibrium temperature of 200°C follows from

$$\tau = (d/2)^2 \cdot 1/æ \qquad (2)$$

where d is the diameter of the discharge tube. If, in equation (2), one sets $æ \approx 10^{-3}$ cm^2/s, a typical value for polymers, then, with a diameter of d = 1 mm, one obtains τ = 2.5 seconds and, with d = 1.26 mm, τ = 4 seconds.

The melt can therefore be heated from 130°C to 200°C within the maximally allowable dwell time of 4 s when it flows through a discharge tube with a diameter of 1.26 mm. With an acceptable tube length l = 10 cm, the following liquid throughput is therefore obtained

$$\frac{dV}{dt} = \frac{\pi}{4} d^2 \frac{l}{\tau} = \pi\, æ\, l = 113 \text{ ml/h},$$

independent of the tube cross-section $q = \pi d^2/4$ and the retention time τ, but directly proportional to the tube length l. This calculated volume throughput of 113 ml/h is technically entirely inadequate. If one considers an attainable throughput of approximately 100 l/h, an increase by a factor of about 1000 would be required to achieve it.

It is the object of this invention to provide a device for heating liquids and melts rapidly, in particular polymers that harden rapidly, which are to be carried through one or more discharge tubes having a small cross section, which provides the desired temperature increase within the required short heating times with as high a liquid throughput as possible.

This objective is achieved by means of the subject of claim 1.

The problem described above is solved according to this invention in that, on one hand, with the inventive discharge tubes, the heat diffusion path of the resulting thermal front and, correspondingly, the heating times, are comparatively short and, on the other hand, the effective tube cross-section is increased by a large factor of 100 to 1000. This is possible because a uniformly short heat diffusion path is provided over the entire cross-section and length of the tube. In this manner, the desired rapid heating at high volume throughputs can now be achieved in relatively short tubular sections having a length of, for example, 10 cm. It is furthermore ensured that melts that harden rapidly can be completely expelled, without retaining hardened residues which make the device inoperable in the tubular structure or in the subsequent narrow discharge tube.

A simple embodiment of the characteristics of this invention is provided by heating wires that are uniformly spaced within the tubular structure, which are so tightly strung along the longitudinal direction of a hollow pipe, preferably having a cylindrical cross-section, that short heat diffusion paths are obtained in the region between the wires. It is furthermore possible to connect numerous (for example 1000) individual tubes in parallel within the tubular structure, for which purpose a preferably solid cylindrical section, made of readily heatable metal, is provided with a suitable number of longitudinal bore holes.

It is also possible, by means of a metal core, to provide an annular channel which also provides uniformly short diffusion path lengths and the desired high throughput when the core is heated.

Particularly effective heating is attainable with a heating tape spiral

Fig. 2 a first example embodiment of the device of this invention.

Fig. 3 a second example embodiment of the device of this invention, and

Fig. 4 a third example embodiment of the device of this invention.

The example embodiments that are shown are all applicable to a rapidly hardenable polymer melt that is pre-heated to 130°C in an extruder, however they are also equally applicable to any other liquids at other exit temperatures. In **Fig. 2A**, the melt **1**, which is pre-heated to 130°C is pressed into a tubular structure **3**, within which a large number, for example 1000, individual tubes with a diameter of 1 mm and a length of 1 to 10 cm are connected in parallel. The individual tubes lead into a single discharge tube **2** having a similarly small diameter through a conical tubular section. If this is desired for purposes of subsequent processing (e.g., nozzeling [?]), two or several discharge tubes, into which the tubular structure **3** leads, can be provided.

The simplest design of this tubular structure is shown in cross-section in **Fig. 2B**. The tubular structure consists of a heatable solid metal cylinder made of a metal having a high thermal conductivity (e.g. copper), with a large number of equally spaced longitudinal holes. The heat transfer from the metal structure can be further increased by stringing heating wires **4** in the interstices between the holes (**Fig. 2C**). Lastly, instead of the drilled holes, it is also possible to tightly pack discrete tubes made of different materials in the manner shown in **Fig. 2C**, where, as in the case of the corresponding drilled structure, heating wires **4** are strung through the interstices between the individual tubes.

In the embodiment in accordance with **Fig. 3**, an annular channel **5** is formed in a hollow tubular structure by means of an inserted core **6** made of a metal having a high thermal conductivity, which is conically tapered at the end facing the discharge tube **2**. Heating coils are located in the inserted core and in the tube wall in the manner shown in the figure, which ensure that the annular channel **5** is heated to a temperature of 200°C. The heating coils also extend into the region where the hollow tubular structure leads into the discharge tube. The annular channel has a large effective flow cross-section, which provides the desired high throughput with a length l of the tubular structure to the exit from the discharge tube of, e.g., 10 cm. Furthermore, the distance between the inside of the hollow tubular structure and the inserted core **6** is selected such that it maximally corresponds to about one half the thermal diffusion path length required by the thermal front emanating from the heated wall or respectively from the inserted core to heat the melt in the required short time. It is thus ensured that the entire melt is uniformly heated. As an alternative to the use of heating coils, the tube wall and the inserted core can also be subjected to a direct current flow, by connecting these structures to a voltage supply.

Fig. 4A shows a device with particularly effective heating. A heating tape spiral **7**, which is rolled up across the longitudinal axis of the tube and which is shown in cross-section in **Fig. 4B**, is located in a hollow tubular structure of length l, e.g., 10 cm. At the short end facing the discharge tube **2**, the heating tape spiral is tapered according to the taper of the hollow tubular structure which transitions into the discharge tube. In the center of the heating tape spiral **7** and at its outside edge, i.e. the sheet metal side, a thin metal bar **8** is soldered on, whereby a voltage is applied to the two rods, by means of which the heating tape can be readily heated to, e.g., 200°C, due to the passage of an electric current. The gaps between the individual tape positions and the sheet metal thickness are each 1 mm in this example embodiment. With an overall diameter of the heating element shown of 10 cm, an effective flow cross-section of 40 cm^2 can be attained with this design. With a required retention time of 2.5 seconds (with d_{eff} = 1 mm) and an effective length of the tubular structure l of 10 cm, the throughput of the melt is

$$dV/dt \approx 40\ cm^2\ l/\tau \approx 160\ cm^3/s \approx 580\ l/h.$$

With such a "heating cartridge", the technical requirements for polymer throughput are therefore ensured within the allowable times and under optimal geometric conditions.

Depending on the overall diameter D of the heating element, any smaller heating cartridge in accordance with **Fig. 4**, with the same gap d of 1 mm, would provide a maximum throughput of

$$dM/dt = \pi D^2 l\rho/(8\tau) = 8.5D^2$$

where D is in cm, τ = 2.5 s, l = 10 cm and ρ = 1.5 g/cm^3

In these conditions, the values listed in the following table are obtained with various diameters D.

	D [cm]						
	4	5	6	7	8	9	10
dM/dt [kg/h]	136	212	305	416	543	689	850

As also in the example in accordance with **Fig. 2**, the connected discharge tube **2** is so short that, due to the high speed of the melt, no additional heating needs to be provided in this flow section. If the discharge tube is made of thermally conductive metal, it will also be at the temperature of the attached tubular structure.

In these examples, electrical heating devices were used exclusively. However, these can, e.g., also be supplemented by other means, e.g. microwave heaters. The cross sections of the tubular structure are additionally not neces-

Claims

1. Device for rapidly heating liquids and melts, in particular polymer melts that harden rapidly, which are to be carried through one or more discharge tubes having a small cross section, **characterized by** a tubular structure located behind the discharge tube(s), having a flow cross-section that is much greater than the cross-section of the discharge tube, and by devices which provide a short heat diffusion path, appropriate for rapid heating times, for the purpose of heating over the entire flow cross-section and the overall length of the tubular structure.

2. Device according to claim 1, characterized in that the tubular structure consists of a hollow tubular section, which leads into one or more discharge tubes and in which heating wires are strung in parallel along the longitudinal direction of the tubular section of these devices, whose mutual spacing is set to the desired heat diffusion path length.

3. Device according to claim 1, characterized in that a large number of individual parallel tubes having a small cross-section in comparison with the cross-section of the discharge tubes (2) it is located within the tubular structure (3), which together provide the increased flow cross-section and which lead into one or more discharge tubes, and that each of these individual tubes is surrounded by a heating device (4).

4. Device according to claim 3, characterized in that the tubular structure (3) consists of a solid, preferably cylindrical, heatable metal body in which single tubes are located in the form parallel, longitudinal holes, whose equal distances are set to the desired heat diffusion path length.

5. Device according to claim 3 or claim 4, characterized in that heating wires (4) are strung between the individual tubes.

6. Device according to claim 1, characterized in that the tubular structure consists of a hollow, preferably cylindrical tubular section, which leads into one or more discharge tubes (2) and in which a solid core (6) made of metal is inserted, which forms an annular channel (5) having the desired flow cross-section with the tubular section, and that both the core and the tube wall which are separated by at a distance approximately corresponding to the heat diffusion path length, are heatable.

7. Device according to claim 1, characterized in that the tubular structure consists of a hollow, preferably cylindrical tubular section, which leads into one or more discharge tubes (2), which is filled with a heating tape spiral (7) that is rolled up across the longitudinal axis of the tubular section with a gap width whose flow cross-section is set to the desired heat diffusion path length.

2 pages of drawings are attached

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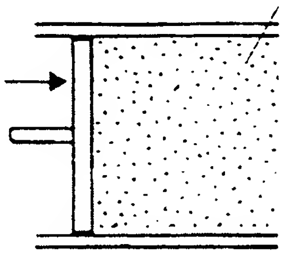

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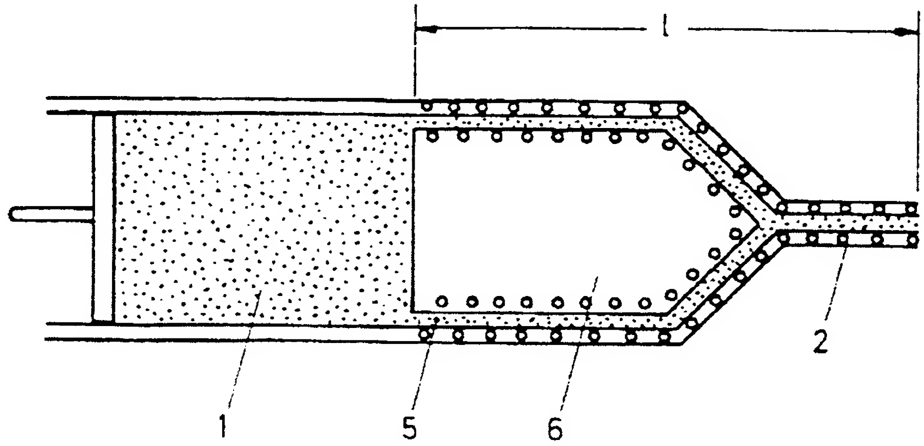

Fig. 3

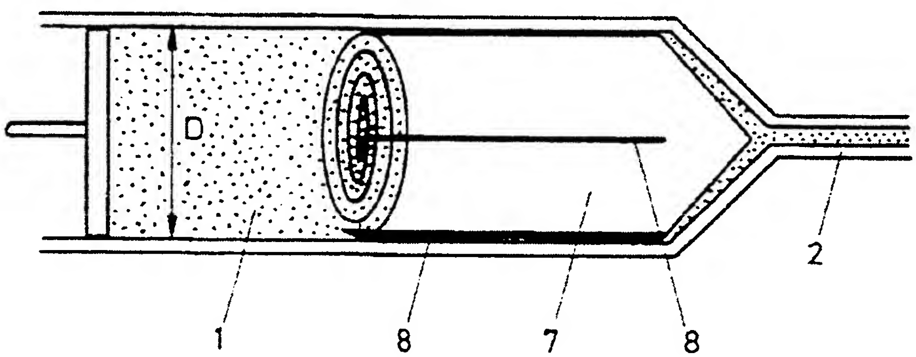

Fig. 4A

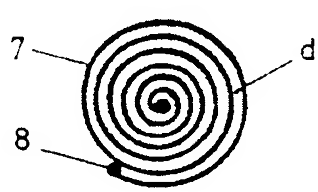

Fig. 4B